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8. Concept and Practices Under Conservation Agriculture

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Abstract:

In order to prevent soil and environmental degradation while maintaining crop production, conservation agriculture (CA) is characterised by low soil disturbance, diversified crop rotations, and the surface crop residue retention. To get around the traditional use of tillage operations, CA includes modifying a number of standard farming practises as well as farmer's mindset. It was discovered that land preparation costs 25-30% more than other operations, which can only be lowered by implementing high conservation tillage practices such as zero tillage, minimum tillage, happy seeders, laser levellers, and so on. Despite the fact that CA adoption is rising across the board, in some places it is either minimal or nonexistent. Although CA adoption has advantages for both agriculture and the environment, there is a lack of knowledge regarding the interactions and effects of key CA components, which affect yield and prevent CA adoption. Conservation agriculture crop can be increased food security, climatic resilence, soil nutrion, income and energy reduction. Farmers are facing the problem of labour shortage and drudgery of farming these can be minimized by conservation tillage practice.

8.1 Introduction:

The concept of conservation agriculture is relatively using of new and modern cultivation practices. Traditional agricultural methods encourage significant soil tillage, crop residue burning, and external inputs. Due to erosion, compaction, and loss of organic matter, these practises degrade the soil. More than 70–75 percent of farmers in India are small-scale landowners who continue to use conventional farming methods and play a significant role in the nation's overall food supply. However, many people find farming difficult, frequently using only the most basic tools and equipment. The majority of farmers pay little attention to long-term resource management and rarely have the money for inputs like high-quality seeds, fertiliser, large machinery, and herbicides for chemical weed control.

The goals of conservation agriculture are to (i) produce at high and sustained levels, (ii) maximise profitability, and (iii) protect the environment. Additionally, it says that improving natural biological processes above and below the soil surface is the foundation of conservation agriculture.

These offer a variety of technological and management alternatives that go beyond zero-tillage. Practically all types of crops, including cereals, horticulture, and plantation crops, can benefit from conservation agricultural practises. These are more common in maize, soybean, rice, and wheat, though. The potential of conservation agriculture practises for various soil types and agro-ecological systems is enormous.

A. What is Conservation Agriculture?

CA is a farming method that can restore degraded soils while preventing the loss of arable land. It improves biodiversity and natural biological processes above and below the ground, which help boost the efficiency with which water and nutrients are used and help sustainably raise crop yield.

Is it a method of farming that enhances, conserves, and makes sure that natural resources are used effectively? It tries to assist farmers in making a profit while maintaining output levels and protecting the environment.

B. Why Conservation Agriculture?

- Because the needs of the constantly growing human and livestock populations cannot be addressed by traditional farming practises.
- Land degradation can be stopped and reversed by conservation efforts, and conservation agriculture enhances productivity while minimising land degradation and boosting food security.

8.2 Principles of Conservation Agriculture:

8.2.1 Permanent Organic Soil Cover:

In conservation agriculture, a permanent soil cover is essential to prevent the soil from suffering negative effects from exposure to rain and sunlight, to maintain a constant food supply for soil micro- and macroorganisms, and to alter the soil's microclimate for the growth of soil organisms and plant roots.

According to Ghosh et al. (2010), this enhances soil aggregation, carbon sequestration, soil biological activity, and biodiversity. Biomass from crop residues, stubbles, and cover crops is used to create soil cover.

According to FAO (2014), crop residues should cover at least 30% of the total farmed area. There are three groups based on the amount of land surface cover: greater than 90%, greater than 61%, and between 30% and 60%.

8.2.2 Diversified Crop Rotations:

A diverse crop rotation is necessary to feed the soil microorganisms and to enable the crops to use nutrients that have been leached into the soil from various soil layers. Rotating deeply rooted crops with shallowly rooted ones will help.

Additionally, a variety of crops in rotation results in a variety of soil fauna and flora. Legumes have an important role in crop rotations because they help biological nitrogen fixation, reduce pest infestation by disrupting the life cycles of the pests, and increase biodiversity (Kassam and Friedrich, 2009; Dumanski et al., 2006).

8.2.3 Minimum Mechanical Soil Disturbance:

In general, soil biological processes are anticipated to result in extremely stable soil aggregates as well as pores with a range of sizes that allow for adequate air infiltration and water infiltration.

The biological soil structuring activities disappear with mechanical soil disturbance caused by tillage or other farming techniques.

In order to maintain the ideal composition of respiration gases in the root zone, moderate soil organic matter oxidation, appropriate porosity for soil water movement, retention, and release, and to prevent the re-exposure and germination of weed seeds, minimal soil disturbance is required (Kassam and Friedrich, 2009).

A. Difference Between Conventional Agriculture and Conservation Agriculture:

Table 8.1: Difference Between Conventional Agriculture and Conservation Agriculture

Conventional Agriculture	Conservation Agriculture
Excessive tillage and soil erosion	No till/ drastically reduced tillage
Crop residue burning or incorporation	Surface retention of residues
Use of ex-situ FYM/ compost	Use of in-situ organic/ compost
Free use of farm machinery	Controlled use or low use of farm machinery
Incorporation of green manure	Surface drying of green manure
Crop based management	Cropping system-based management
Single crop or sole crop is grown	Intercropping/ relay cropping
Uneven field levels	Precision laser land levelling

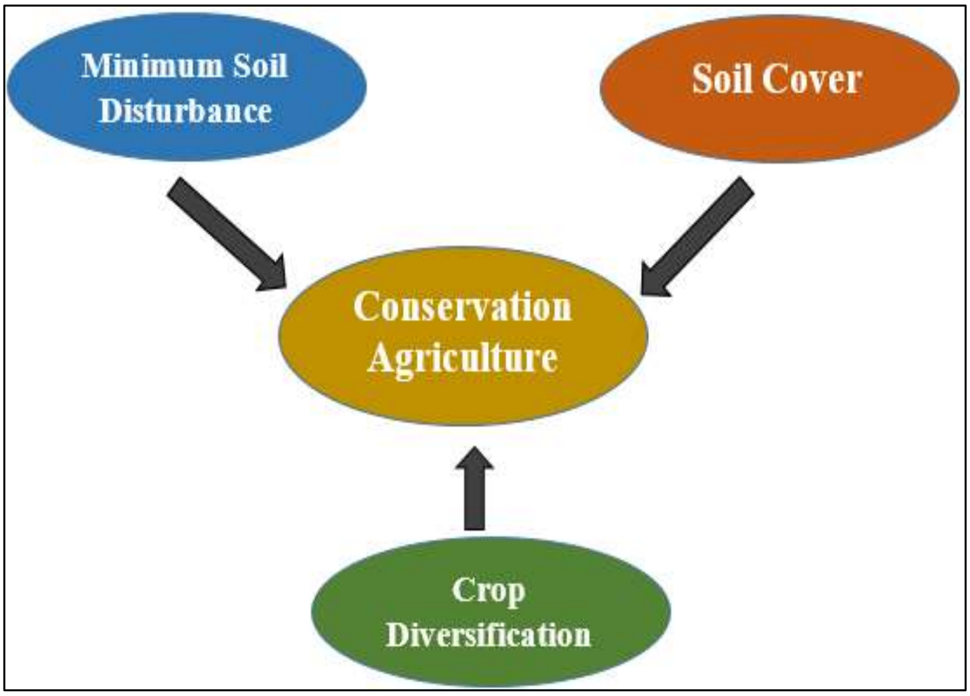

Figure 8.1: Conservation Agriculture

B. Agronomic Interventions Following Conservation Agriculture Principles for Improving Crop Yields

- Conservation tillage
- Permanent soil cover
- Diversified crop rotations
- Soil and water conservation practices
- No burning of residues
- Direct sowing

8.3 Conservation Tillage Practices Include:

A. Zero Tillage: Primary tillage is completely avoided and secondary tillage restricted to seed bed preparation in the row zone only.

B. Minimum Tillage:

- Reducing tillage to the minimum necessary for ensuring a good seedbed.
- It involves soil disturbance, to lesser extent. Keeps 30-50% crop residue on soilsurface

C. Stubble Mulch Tillage: Soil is protected all the times by growing crop or crop residue left on the soil surfacebetween two crops.

D. Ridge Tillage:

- Ridge-tillage cultivator removes weeds, loosens the soil and builds up the ridge at a time.
- seeds are placed in the center of the ridge.

E. Weed Control: In CA systems, weed control is seen as a severe issue, and successful weed control is essential to system success. In order to reduce the energy reserves in the various storage organs or roots of weeds, many tillage activities are necessary to control perennial weeds.

8.4 Status of Conservation Agriculture and Its Extent of Adoption in India:

According to Farooq and Siddique (2014), farmers in India are estimated to be using no-till techniques on about 1.5 million acres of land for crops such maize, millets, sorghum, pigeon pea, cotton, and chickpea as well as in rainfed upland areas. The area under conservation agriculture in the rice-wheat and rice-maize cropping systems has significantly risen over the past ten years. Through the combined efforts of various State Agriculture Universities and Indian Council of Agricultural Research (ICAR) institutes, conservation agriculture practises have undergone significant testing. The Rice-Wheat Consortium, which was part of the CGIAR system, supported the adaptation, promotion, and development of these practises. As a result, farmers in the IGP belt (Haryana, Punjab, and Western Uttar Pradesh), which covers about 2 M hectares, are quickly adopting these technologies. According to research from IARI (2012), farmers in the northwest are also adopting conservation agriculture practises such furrow irrigation raised-bed planting, laser assisted field levelling, unpuddled mechanical transplanting of rice, and residue management practises. Intercropping systems like maize + potato + onion + red beets or sugarcane + chickpea + Indian mustard are also gaining popularity among farmers in western Uttar Pradesh (Gupta and Seth, 2007Zero-tilled (ZT) wheat has been widely used in the rice-wheat cropping (RW) systems in the northwestern IGP, and recently, its use has also begun to rise in the eastern IGP (Malik et al., 2005). According to Smart Indian Agriculture (2015), under the direction of the ICAR Directorate of Weed Research, conservation agricultural technologies have recently been successfully tested on farmer farms in Madhya Pradesh's district of Jabalpur. According to their findings, conservation agriculture is the fastest-growing farming method in this area, and the black cotton soils of central India are among the best ones for it. The long-term study on various conservation agriculture-based systems, started under AICRP weed management, has produced encouraging results for maize-sunflower in Tamil Nadu, pearl millet-mustard in Gujarat, and rice-chickpea-green gramme in Karnataka, pointing towards the potential for extending the advantages of conservation agriculture to central and south India (DWR, 2014).

8.5 Conservation Agriculture Benefits:

- Improvement of soil quality, i.e. soil physical, chemical and biological conditions.
- In order to reduce pollution from greenhouse gasses and to allow growth processes greater resistance to climate-related aberration, enhancing sequestrationof soil in C and building up organic matter is a realistic approach.

- Lessening of the occurrence of weeds.
- Increasing of nutrient and water use efficiency.
- Increasing of production and productivity (4% – 10%).
- Sowing can be done early.
- Greenhouse gas emission reduction and enhanced environmental sustainability.
- Preventing seed residues from combustion decreases fertilizer depletion and contamination of the atmosphere, which eliminates significant health harm.
- Opportunities to diversify and increase crops, such as sugar cane systems, mustard, chickpea, pigeon pea etc.
- Enhance the efficacy of resources use by decomposing residues, improving the structural conditions of soil, increasing recycling and access to plant nutrients.
- To keep an eye on the grass and soil temperature, reduce evaporation, and promote agricultural growth by using surface leftovers as a polkway. The benefits of the ZT wheat technology are being tested and employed in various Indian agricultural methods, but there are substantial knowledge gaps in the use of CA-based technology, which suggests that such technologies need to be developed, improved, popularised, and extensively disseminated.
- Decrease in production cost.

8.5.1 Economic Benefits:

To monitor the temperature of the grass and soil, lower evaporation, and encourage agricultural growth by using surface waste as a polkway. However, there are significant knowledge gaps in the application of CA-based technology, which shows that such technologies need to be created, enhanced, popularised, and widely distributed. The advantages of the ZT wheat technology are being evaluated and applied in various Indian agricultural approaches. Erenstein and Laxmi (2008) claim that planting ZT-wheat in India after rice increases farmers' revenue from growing wheat (US$97/ha) as a result of the combined impacts of yield enhancement and cost-saving (Table 1). In a similar vein, Gupta and Seth (2007) found net gains from ZT-wheat in India of $150/ha.

8.5.2 Environmental Benefits:

Resources are used more skillfully in conservation agriculture than in traditional agriculture, making them available for other uses and preserving them for future generations. Increased crop diversification, improved soil biological processes, lower erosion and leaching, and reduced long-term usage of inorganic fertilisers and pesticides can all result in greater water and nutrient retention and efficiency.

Through increased water infiltration and less surface runoff, ground water supplies are refilled. As a result of less pesticide pollution and soil nutrient leaching and soil erosion, water quality is also improved (Bassi, 2000). ZT agriculture significantly minimises the need of fossil fuels, which lowers greenhouse gas emissions and maintains the biome's cleaner air. Additionally, conservation agriculture significantly reduces air, soil, and water pollution by using less agrochemicals. Given the potential for global warming, conventional tillage produces more greenhouse gas emissions than zero tillage under both wheat and rice cropping systems.

8.5.3 Benefits in Resource Conservation and Improvement:

According to studies by Dahiya et al. (2007), Verhulst et al. (2010), Jat et al. (2012), Saharawat et al. (2012), and others, conservation agriculture (CA) is a strategy for improving water use efficiency in a sustainable manner by increasing soil water infiltration and retention, reducing evaporation loss, improving nutrient availability, and reducing the prevalence of weeds like Phalaris minor in wheat. Crop growth and production are enhanced or maintained as a result of CA practises (Aulakh et al., 2012; Krishna and Veettil, 2014; Yadav et al., 2019). Its long-term benefits in promoting crop yield, increasing water and nutrient uptake, reducing soil erosion, and attenuating the consequences of climate change are of utmost significance. Let's do a methodical recall.

8.5.4 Soil Physical Health:

A crop must have the right soil conditions for it to grow and develop properly. Therefore, it is necessary to understand how conservation agriculture affects the physical quality of soil. Conventional tillage (CT), which involves frequent and intensive tillage operations, physically degrades soil structure, whereas decreased or no tillage preserves soil aggregation due to less soil disturbance and the intact presence of intact root fragments and mycorrhizal hyphae as binding agents. In contrast to Connecticut,

where there is no permanent crop residue, conservation agriculture protects the soil against wind, water, and rain drop erosion. Conservation agriculture maintains larger aggregates (Bhushan et al., 2007), higher mean weight diameter (Jat et al., 2009), and reduces the impact of many constraints related to soil physical health degradation, such as soil structure degradation, soil compactness, soil crusting, and decrease in soil organic matter (Dalal et al., 1996). By increasing soil organic carbon content, zero tillage improves soil aggregate stability (Chauhan et al., 2002).

8.5.5 Crop Productivity:

Due to a loss in agricultural output in the first few years after CA implementation, farmers are typically reluctant to implement it. However, numerous studies have found that CA either have no effect on crop productivity or have a favourable influence. Krishna and Veettil (2014) investigated the effects of implementing zero tillage on farms in Haryana and found that crop productivity increased by 5%. In the eastern and north-eastern regions of India, the adoption of conservation tillage, along with better plant nutrient management and 30% residue retention for three years, increased grain yield by 51.1–52.2% in comparison to farmer practises at the time (Yadav et al., 2019).

According to Das et al. (2014a), conventional tillage produced a larger yield of rice grains than minimum tillage. However, after four years, the soil quality and nutrient recycling increased and the yield stabilised with minimum tillage. According to Jat et al. (2013), wheat crop had significantly higher yield under no-till flat system during first year and non-significant difference in succeeding two years. Maize crop produced higher grain yield under permanent raised beds system as compared to no-till flat and conventional flat system. As a result, CA practises may be advantageous.

8.5.6 Water and Nutrient Use Efficiency:

Through its effects on mineralization, recycling of soil nutrients, moisture retention, and controlled evaporation, tillage, residue management, and crop rotation significantly influence the physical environment of the soil and the dynamics of water and nutrients in any soil. In the Indo-Gangetic plains of India, wheat is typically grown using zero tillage. Zero tillage can save 20 to 35 percent more irrigation water on wheat crops than conventional tillage (Mehla et al., 2000; Gupta et al., 2002). By using the remaining moisture from the paddy crop's harvest instead of pre-sowing irrigation, this practice helped save water for the wheat crop. Additionally, the practice enabled earlier wheat crop planting and harvesting, which further reduced the need for one or more irrigations in the late season.

The irrigation water productivity in the winter months was boosted by 39–138% over the conventional system in the eastern Indo-Gangetic plains by incorporating the CA components (Laik et al., 2014). on an experiment on a maize-wheat cropping system on sandy loam soil, Jat et al. (2013) found that permanent raised beds had a 16% greater water use efficiency than conventional tillage. Permanent raised beds and no-till flat treatments required less irrigation water, by 24.7% and 10.8%, respectively, than the conventional tillage treatment. In the cropping system for pigeon pea and wheat, the CA system had a greater water use efficiency than the CT system (Das et al., 2016). In the northwestern Indo-Gangetic plains, CA-based plots reduced evaporation by 23–37% compared to CT-based plots (Parihar et al., 2019). Here, the permanent raised bed plots had water productivity that was 14-35% and 30-36% higher than the zero-till and conventional-till plots, respectively.

8.5.7 Soil Erosion Control:

Without control, soil erosion results in the loss of fertile top soil, which reduces sustainability, while also causing water bodies downstream to become sedimented and atrophied. According to research on CA practices, runoff, which is otherwise responsible for transferring soil sediments and residual agrochemicals, is reduced (Kukal et al., 1991). This has an impact on both surface and ground water contamination. According to Kurothe et al. (2014), there was a 37.2% decrease in average soil loss when compared to conventional tillage. In comparison to conventional tillage, the runoff under ridge farming tillage, no tillage, and stubble mulch farming tillage was reduced by 69.4, 16.2, and 59.6 percent, respectively.

8.5.8 Climate Change Mitigation/Adaptation:

CA has the potential to help with adaptation and mitigation for extreme weather events that happen as a result of climate change. By using less fuel during reduced tillage operations and by enhancing soil organic carbon retention, CA can lower the release of atmospheric greenhouse gases (GHGs) and aid in mitigating climate change. By combining decreased tillage with enhanced plant nutrient management (IPNM) and 30% rice residue retention in wet season rice, 1.30 Mg C ha-1 was amassed with a sequestration rate of 427.9 kg ha-1 yr-1 in a rice-rice cropping system. According to reports, implementing CA with IPNM/INM and residue retention or incorporation had the ability to reduce CO2 emissions by about 1.6 Mg ha-1 yr-1 in paddy soil, which can help to mitigate climate change (Yadav et al., 2019).

Conservation agriculture on permanent bed systems, with crop residue retention in the maize-mustard-mung bean cropping system, and nitrogen treatment with neem coated urea, according to Jat et al. (2019b), can reduce carbon footprint and is therefore an environmentally secure and effective practise.

8.6 Management Practices Concentric to Conservation Agriculture:

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8.6.1 Conservation Tillage Practices:

Conservation tillage techniques include mulch tillage, ridge tillage, contour tillage, reduced or no tillage, and minimal tillage. There is no soil surface disturbance caused by tillage in no-tillage (NT). Only a small portion of the soil's surface is disturbed when seeds are sown. There is no secondary tillage work done in minimum or reduced tillage.

When using mulch tillage, the soil is tilled so that the residual crop wastes can cover the greatest possible area of the soil surface. Crops are planted either on top of or on either side of the ridges that are prepared during sowing in ridge tillage.

8.6.2 Residue Management Practices That Avoid Burning:

All residue management techniques that prevent its burning are beneficial to the environment and natural resources in one way or another. The management of crop wastes under Indian conditions may include mulching, conservation agriculture, composting, mulch tillage, biochar production, and animal feeding. Crop residues, whether left on the soil surface as mulch or incorporated as compost, biochar and farm yard manure (FYM) from animals, typically protect the soil surface from extremes of rainfall and temperature.

They also increase the activity of different soil macro and micro-organisms, which further aids in the formation of stable soil aggregates. Crop residues lessen soil aggregate dispersion and breakdown as well as surface compactness, surface sealing, and crusting.

According to Ruan et al. (2001), various bio-physical factors like soil type, topography, temperature, intensity and amount of rainfall, wind speed, amount and magnitude of soil surface cover by crop residues, and common cropping patterns all influence how much crop residue cover has a positive impact on a region. More land surface cover increases the preservation of soil physical qualities against natural and artificial disturbances, according to Blanco-Canqui et al. (2006). In a four-year study on permanent bed systems, Jat et al. (2019b) found that applying agricultural residue boosted productivity by 11.7% relative to a system without residue.

8.6.3 Crop Diversification Practices:

Beyond conservation tillage and residue management, crop rotation is a key element of conservation agriculture. The types and characteristics of the crops used during crop rotation define the degree and scope to which soil physical health may be altered. Proper crop rotation makes it easier for different micro- and macro-pores to form, which is necessary for the circulation of water, air, and nutrients into the soil and is good for crop root growth. According to Jat et al. (2019b), growing maize, mustard, and mungbeans in a permanent bed system of conservation agriculture had a benefit-cost ratio that was 11% higher, more net energy, and a 9% lower carbon footprint than growing maize, wheat, and mungbeans.

8.6.4 Nutrient and Water Management Practices:

Since CA influences different physical, chemical, and biological properties of soil, which in turn dictate the nutrients and water availability, it is necessary to improve nutrient and water management practises with respect to CA in order to gain maximum benefits and sustainability. According to Jat et al. (2019b), application of nitrogen using neem-coated urea in permanent beds with crop residue increased system production by 10.9% compared to non-coated prilled urea. In a study that lasted four years in a soybean-wheat cropping rotation in the northwestern part of the Indo-Gangetic plains with soil that had a loamy sand texture, low levels of organic carbon, and available phosphorus, Aulakh et al. (2012) found that soybean productivity could be increased under conservation agriculture as compared to conventional agriculture either by applying 25 kg of manure per hectare per year or by using a combination of both.

8.6.5 Weed Management Practices:

The main and most frequently mentioned barrier to farmers' adoption of CA is the shift in weed species and rise in weed density, which reduce agricultural output. Numerous experts claimed that although their degree of adoption is now relatively low, cover crops may be essential for weed management in CA systems. Alterations to planting methods, tillage patterns, and other management techniques can drastically alter the weed flora by altering the soil environment. Herbicide use has been a crucial part of managing weeds in CA systems, but more work needs to be done to combine it with non-chemical weed control methods.

8.7 Effect of CA On Crop Yields:

Concern over conventional agricultural practices, particularly soil tilling with a plough, disc, or hoe, is developing in many regions of the world due to the negative effects they have on the environment and the productivity of soils. This prompted both governments and farmers to find other methods of production that maintain the productivity and soil structure. When there is little or no tillage, the use of cover crops, extensive field rotations, and straw mulches is frequently an obvious and popular option to preserving grass (Knowler and Bradshaw, 2007). CA is a significant and inescapably detrimental departure from the current management for many active farmers. For farmers who aren't ready to accomplish this, reduced tillage options are a practical option.

The combination of decreased tillage (with the aim of no tillage) and other characteristics of CA practises led to the development of sustainable intensification conservation agriculture (CASI), with the goal of increasing cultivation schemes in a sustainable manner.

Over the past thirty years or so, the IGP has tested CASI technology, particularly in RW systems. In comparison to traditional labor-intensity (CT) approaches, the adoption of Zero Tillage (ZT) and residue preservation for wheat has been shown to increase yields, flexibility in resource usage, soil and water quality, and lower production costs (Islam et al., 2019). Permanent vegetative covering or flour cover, low ground disturbance (No/reduced tillage), and numerous crop rotations are the three main tenets on which CA is often based. Due to CA's positive impact on the preservation of land and water, human safety, and economic viability, it has been recognised as an environmentally benign technology and used internationally. Despite rising food security globally, there are worries regarding the effects of CA practises on crop output, particularly in underdeveloped nations (Zheng et al., 2014). The impact of CA on crop output may be complicated. For instance, CA can boost crop yields by boosting soil fertility by preserving soil and water and storing organic carbon in agricultural fields (Holland, 2004). In comparison, CA may also havedetrimental effects on crop yield by modifying soil physio-chemical and biological conditions, such as growing soil temperatures in high latitudes or low temperature seasons and aggravation of temperatures in agricultural areas. The true effect of CA on crop yields will mostly be calculated by different CA methods, national climatic conditions and crop systems (Liu *et al.,* 2010). Numerous crops grown around the world that are focused on conservation have shown increases in yield. For instance, Thierfelder et al. (2015) found that conventional labour produced more maize (Zea mays L.) than other methods in South Africa. Between conservation agricultural and laying plans, maize and other crop yields have been documented not only in African nations but also in North, Latin American, and Asian countries (Kassam et al. 2009; Faroooq et al. 2011). The main causes attributed to better yields include enhanced soil fertility over the long term and improved soil physical conditions (such as improved infiltration and retention of soil moisture). Increased farmers' experience was lacking, slow fertility rate increased, water stock in high rainfall periods was reduced on poorly drained soils, cultivation of delayed crops due to the occurrence of wet and cold soil fertilisation, residue management issues, and increasing weed competition (Linden et al. 2000; Faroooq et al. 2011; Thierfelder et al. 2015).

8.8 Predictions of Conservation Agriculture:

In order to refocus current farming and processing activities with lower pricing by choosing less risky pathways and options, Asian farmers and researchers will also need support. Therefore, continuing with business as usual doesn't seem like a realistic option for conventional farming practices. Sustainable improvements in food grain output and, thus, CA-based crop implementation strategies tailored to particular requirements, would also have to play a significant role in the majority of the ecological and socioeconomic context of Asian agriculture. The following opportunities for fostering CA in theIndian / Asian context:

- Production cost is Reduces
- Weed growing is reduced

- Water and nutrient saving
- Yields of crops increases
- Beneficial for the environment
- Diversification of crops
- Improves the resource use efficiency.

8.8.1 Limitations for Adoption of CA:

Moving farmers, engineers, extenders, and researchers away from land degradation and towards sustainable production techniques is important to bring about a change in farming attitudes (Derpsch 2001). CA is currently a route for sustainable agriculture. Therefore, the advancement of scientific research will be necessary for the growth of conservation agriculture. The widespread adoption of the CA is hampered by a few significant obstacles.

- Lack of seeds for small and medium - size growers, in particular.
- The high utilisation agricultural residues in cattle feed and energy.
- Crop residues burning.
- Failure to realize CA’s value for producers, extension officers and growers.
- Required trained and technical workers.

8.8.2 Bottlenecks for Adoption of Conservation Agriculture:

Apart from the many advantages of conservation agriculture, there are a number of issues that prevent it from being widely used, such as equipment and machinery, weed control, farmer mindset, and policy restrictions. The major obstacles in Indian farmers' adoption of CA are briefly discussed below.

8.9 Lack of Appropriate Machineries:

Although major efforts have been made to develop and market equipment for sowing wheat in no-till systems, it will need far more work to develop, standardise, and encourage high-quality equipment for a variety of crops and cropping patterns if the technology is to be successfully adopted. These would entail the creation of suitable equipment to manage crop residues and carry out simultaneous tasks like uniformly shredding of residues that are typically piled in the field after combine harvest, collection of part of residues for animal feed and application of fertilisers at the proper place and in the proper quantity along with seeding.

In this context, the Australian Centre for International Agricultural Research and Punjab Agricultural University, Ludhiana, have created a novel equipment named the "Happy Seeder." A 45 HP tractor is needed to operate the Happy Seeder machine. In a single operational pass of the field, it cuts, lifts and controls the standing stubble and loose straw by keeping it as surface mulch and sows the wheat crop. However, the machine's weight, the burden on the tractor, and the choking of the machine with a big stubble load are still the main operational restrictions. The development of a super straw system attachment for combines now ensures cutting and even distribution of heaped or anchored wastes in the field. Therefore, this might be a practical way to deal with the residue.

In the case of the Turbo Happy Seeder, the tractor's power demand must be greater than 50 HP. As most farmers own tractors with 40 or fewer horsepower, this presents another barrier to managing residue. In this situation, the farmer won't need to buy a new, high-powered tractor because the draught required for the Turbo Happy Seeder can be decreased by reducing the number of tines. Additionally, farmers are hesitant to buy these devices because they sit dormant for the majority of the year.

8.9.1 Infrastructural Constraints:

A few of the inputs that must be made widely accessible in the market in order to promote CA include herbicides, seeds for rotational and cover crops, and agricultural machinery for direct sowing, planting, and residue management. Many times, these equipment types diverge completely from those that are normally employed. This can be accomplished with improved input supply infrastructure and a proactive attitude on the part of the supply sector, including dealers and manufacturers.

8.9.2 Obnoxious/Stubborn/Resistant Weeds:

Infestation, distribution, diversity, growth style, and resistance levels of weeds have changed throughout California. Herbicide applications over an extended period of time can somewhat suppress weed infestation.

Since herbicidal applications are typically used to manage most weeds, their gradual reappearance over time is a severe issue. But over time, the majority of weeds develop resistance to pesticide use. Even pesticides are ineffective at controlling obnoxious weeds. The quality of crop yield and soil biodiversity may be threatened by the regular administration of herbicides to farms in California to suppress such weed species. Therefore, it may be necessary to redefine the CA and permit one-handed weeding at the proper stage of the crop. It will be the effective method to control weeds without much disturbance to the soil and at the same time save the fields from being overloaded with herbicidal residues.

8.10 Conclusion:

Conservation agriculture covers a wide range of topics, including maintaining agricultural productivity, guaranteeing food security, conserving natural resources including soil, nutrients, and water, and mitigating or adapting crops to climate change conditions. Numerous advantages of conservation agriculture include improved soil physical, chemical, and biological health; sustaining crop production through resource conservation and soil quality; cost, energy, and labour savings; improved water and nutrient use efficiency; reduced greenhouse gas emissions by carbon sequestration; reduced soil erosion and environmental pollution due to the elimination of the need to burn crop residues; and climate change mitigation. Different from the conventional system, CA's management techniques change depending on the soil, crop, and resource availability. Even Nevertheless, there aren't many barriers preventing its widespread implementation. Through the implementation of effective policy, the agricultural clients may easily access suitable farm equipment, particularly for residue management.

The requirements of small and medium farmers must be taken into consideration when developing the agricultural machinery for CA. In addition, the concept of one-handed weeding at the proper crop stage for managing noxious weeds needs to be introduced in order to redefine the phrase "conservation agriculture". In accordance with the conditions in the local area, more research is needed to improve these management practices.

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